SDSU-RSI-75-15

Investigation of Remote Sensing Techniques as Inputs to Operational Resource Management Models

Dr. Fred A. Schmer
Mr. Robert E. Isakson
Remote Sensing Institute
South Dakota State University
Brookings, South Dakota 57006

December 1975
Interim Type II Report for Period September - December 1975

Prepared for
Goddard Space Flight Center
Greenbelt, Maryland 20771

TECHNICAL REPORT STANDARD TITLE PAGE

1 Report No	2 Government Accession No	3 Recipient's Catalog No
3		

4 Title and Subtitle	5 Report Date
Investigation of Remote Sensing Techniques as Inputs to Operational Resource Management Models	December, 1975
	6 Performing Organization Code
7 Author(s) F A Schmer, R E Isakson	8 Performing Organization Report No SDSU-RSI-75-15
9 Performing Organization Name and Address Remote Sensing Institute South Dakota State University Brookings, South Dakota 57006	10 Work Unit No
	11 Contract or Grant No NAS5-20982
12 Sponsoring Agency Name and Address NASA Goddard Space Flight Center Fred Gordon - Technical Monitor Greenbelt, MD 20771	13 Type of Report and Period Covered Type II Interim Sept 11 - Dec. 10, 1975
	14 Sponsoring Agency Code

15 Supplementary Notes Participating South Dakota State Government agencies include the State Planning Bureau the Department of Game, Fish, and Parks, the Department of Natural Resources Development, and the Black Hills Conservancy Subdistrict

16 Abstract NASA and RSI aircraft support flights were completed Work continues on production and evaluation of data products for use in a resource inventory of the Belle Fourche River Basin, forestry typing, and surface water management programs Use of LANDSAT data in a decision-making situation by Game, Fish, and Parks has been documented

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

Original photography may be purchased from
EROS Data Center
[illegible] and Dakota Avenue
Sioux Falls, SD 57198

17 Key Words Suggested by Author	18 Distribution Statement
LANDSAT remote sensing resource management State of South Dakota operational	

19 Security Classif (of this report)	20 Security Classif (of this page)	21 No of Pages	22 Price
U	U	21	

PREFACE

During this reporting period, LANDSAT aircraft support missions were completed Interpretation of LANDSAT and aircraft data continue with state agency participants becoming increasingly involved in the interpretation of data Entry of data into a computerized data base is being evaluated for application in conjunction with remotely-sensed resource information. The entire Belle Fourche River Basin has been interpreted for surface water using LANDSAT transparencies and a Bausch & Lomb Zoom Transfer Scope LANDSAT data has been used by Game, Fish and Parks personnel in mitigation efforts with the U.S Army Corps of Engineers

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

This is the third quarterly report of LANDSAT Follow-On Project, NASA Contract NAS5-20982. Included during this quarter were final LANDSAT aircraft support flights. LANDSAT data is being evaluated by three South Dakota governmental agencies Game Fish and Parks (GF&P), State Planning Bureau (SPB) and the Department of Natural Resources Development (DNRD). The study site is the 810,000 hectare (2,000,000 acre) Belle Fourche River Basin in Western South Dakota.

PROBLEMS

During the first week in September (two weeks prior to the scheduled flight) it was learned that RB-57 aircraft scheduled for the second (final) mission had been grounded. As high altitude aircraft data was a prime source of LANDSAT support/evaluation information, loss of the data would have had serious implications on the conduct of the project. Negotiations for substitute aircraft led to the scheduling of a September 23 NASA - AMES U-2 mission over the test site. Data from this flight has not been received

Problems associated with the project have shifted from those of data collection to those pertaining to the interpretation and application of the data. One of the most difficult aspects of the project continues to be that of getting state officials actively involved in the interpretation procedure. The most simple visual interpretations (e g MSS7 surface water) are foreign and the entire interpretation procedure seems to present itself as an obstacle These problems will begin to alleviate themselves as agency representatives have been given "assignments" for direct input into the evaluation of LANDSAT data and will be guided through

the interpretive processes During this period, the Remote Sensing Institute (RSI) was visited by the DNRD project representative, but not enough time was spent to do more than familiarize the representative with general interpretive procedures and provide guidance to ensure useful products are being generated.

ACCOMPLISHMENTS

The second RSI low-altitude mission over selected areas within the basin was accomplished September 23, 24. The NASA-Ames U-2 provided complete basin coverage September 23, five days prior to a LANDSAT overpass. Aircraft data collection is now completed. Numerous LANDSAT scenes have provided adequate data for evaluation.

The primary emphasis continues to be on producing useable products and on transferring the interpretation skills to participating agency representatives. The initial basin-wide interpretation was a surface water inventory. Entry of this interpreted LANDSAT data into a computerized data base demonstrated a basin-wide application of these two new resource management tools. Similar work on other land use data continues. The late June early July RB-57 and June 25, Sept. 23 RSI low altitude data have been reviewed and are acceptable for use in evaluating LANDSAT data. Use of LANDSAT data proved a valuable asset to GF&P representatives in mitigation efforts by the U.S. Army, Corps of Engineers. Discussion of specific accomplishments will be presented below.

Data Base

Considerable effort has been expended in the evaluation of entering remotely-sensed resource information into a computer-based data system.

MAPCLASS, as the program is called, allows for manual coding of change-points rather than coding every cell in a grid system. The program also allows the computer to "overlay" and manipulate numerous combinations of data entered into the data base. Output via a Calcomp plotter permits maps to be generated at any desired scale.

The basic cell is 16.2 hectares (40 acres). This size was selected because it is small enough to obtain desired detail, but large enough to keep digitizing times reasonable. The grid system itself could have been based on a variety of coordinate systems. Two systems appeared to be the most practical Latitude/Longitude and Range/Township In selecting one of these two systems as the grid base, it was thought the Latitude/ Longitude grid system would be easier to establish, however few South Dakotans are familiar with Latitude/Longitude as a ground reference system. South Dakota is subdivided into townships by a Range and Township grid system and because the nomenclature is widely used and understood, the decision was made to evaluate a data-base grid system based on Range and Township lines. A 1 250,000 base map of the Belle Fourche basin was prepared from 1·250,000 USGS Quadrangle maps. Based on Range correction lines and adjusted Township lines, the basin was divided into eight sections varying in size from eight to 30 townships (93.3 km^2, or 36 mi^2 per township) each. These eight sections are essentially square in themselves and are each the basis of an individual grid system. Tne sections represent grids with 96^2 or 144^2 cells each. The grid system was generated using the Calcomp plotter and associated software With the grid system established, it remained to evaluate the digitizing procedure and the practicality of the results.

Department of Natural Resources Development

The Department has a Legislative mandate to conduct resource inventories of the State's nearly 20 river basins, develop a statewide resources management plan and update the inventories every four years One of the major reasons for DNRD entering this project was for conducting an evaluation of remote sensing in providing portions of the required data DNRD personnel desire evaluation of data products possessing immediate applicability Discussions led to the decision to interpret the entire Belle Fourche River Basin for surface water using LANDSAT data. The first surface water interpretation was conducted using 1 1,000,000 LANDSAT MSS7 transparencies on a Bausch and Lomb Zoom Transfer Scope (ZTS). The image was registered to a 1 250,000 USGS Quad map of the area. The field of view of the ZTS allowed up to nine townships to be viewed at one time. Once registered, drafting-quality paper was placed over the map and the surface water was traced onto the paper using drafting pens. Interpretations were separately conducted for each of the eight sections. For registration during digitization, the corners of these sections were traced from the map onto the paper. Evaluation of other scales and interpretation of prints will be conducted in subsequent studies.

Entering the data into a MAPCLASS data base was accomplished by manually coding the location and approximate size of the interpreted water. The water was classified into one of six categories single water bodies of 0.4-4 0 ha (1-10 acres) 4.5-8.1 ha (11-20 acres), 8.5-16.2 ha (21-40 acres) per cell, or two, three, or four 0.4-4 0 ha (1-10 acre) bodies of water in a single cell. The size was approximated by

visual comparison of the interpreted water with the basic cell unit. Major river/stream systems were also entered into the data base. MAPCLASS tabulates the frequency and total area involed in each of the classifications so for each of the eight sections there is available a printed summary of the occurrence of interpreted surface water. Figure 1 shows digitized LANDSAT surface water data superimposed on a 1954 USGS map The LANDSAT image with the same overlay can be seen in Figure 2. Discrepancies between the map and the interpretation and between the interpretation and actual ground conditions are being evaluated

Table I contains data on the interpretation/digitizing procedures for the surface water inventory. As can be seen, the time required to manually digitize data is substantially greater than the required interpretation time. Using a figure of $10/hr for photo interpretation and $4/hr for general labor, the total costs are found in Table II. Estimated material costs of $50 included LANDSAT MSS7 data, pens, maps and paper. The cost of the ZTS was not included. It should also be stated that experimental procedures and developmental time has not been accounted for in this cost summary. Based on the figures contained in Table II, an interpretation of surface water (from LANDSAT data) can be conducted and entered into a data base for approximately $.05/km^2. ($.12/mi^2). Additional interpretations will provide more data to refine cost estimates.

Because of the time involved in manually digitizing data, an evaluation of an automated data entry procedure was initiated. The method combines the visual interpretation data with the image digitizing capabilities of RSI's Signal Analysis and Dissemination Equipment (SADE)

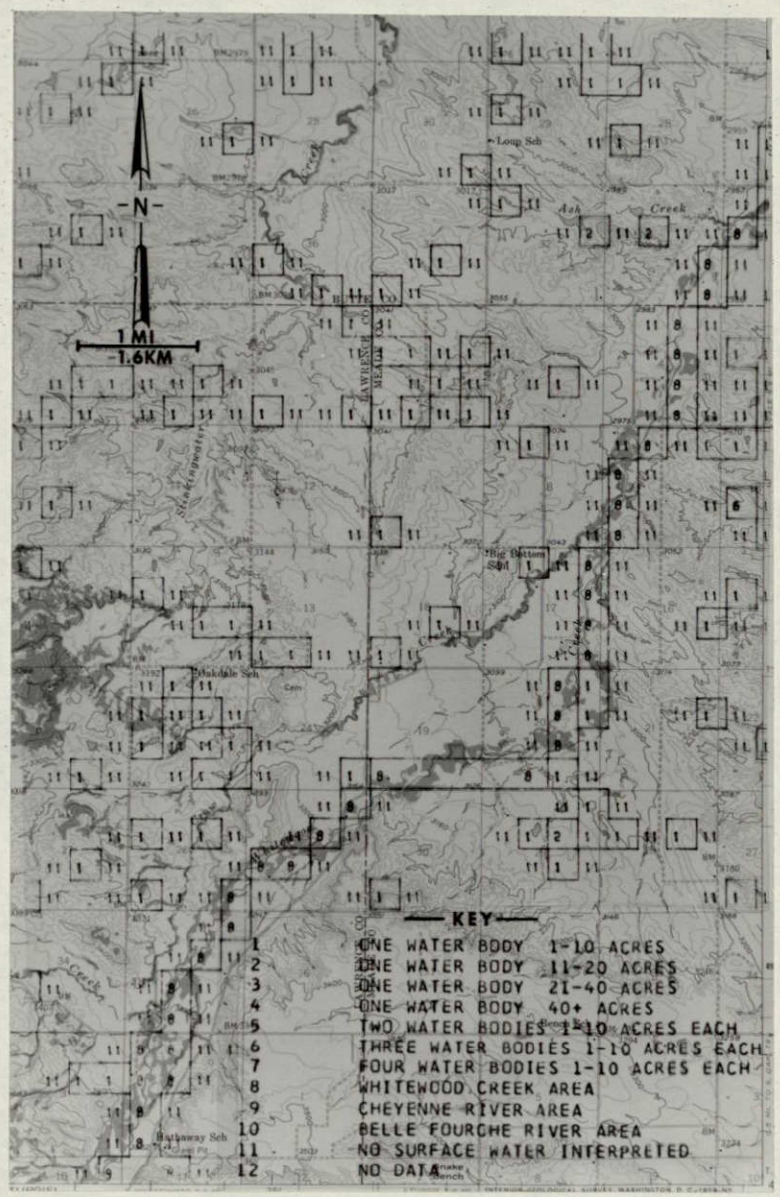

Figure 1. Digitized 12 Jun 75 LANDSAT MSS7 data superimposed on 1954 USGS map.

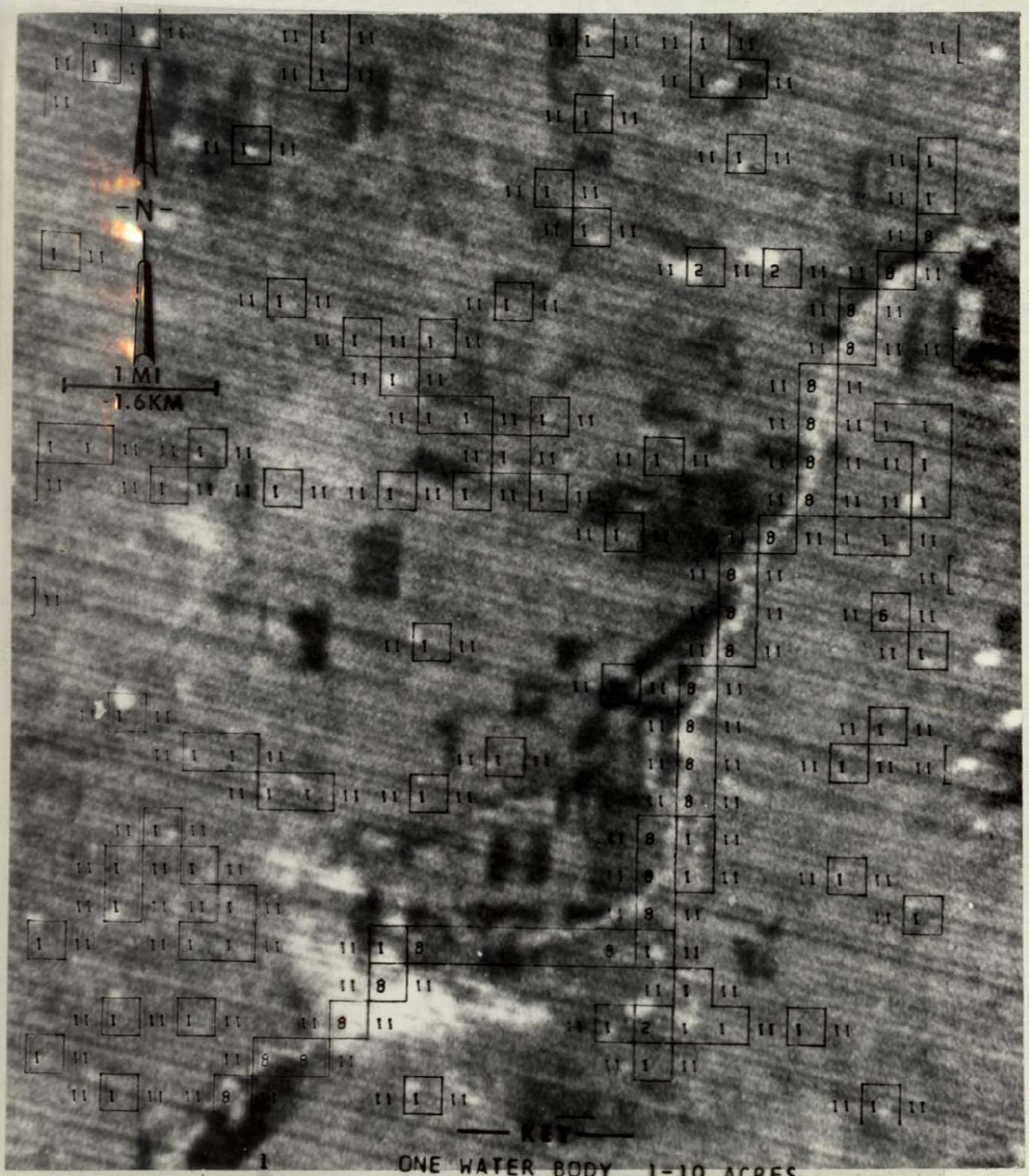

Figure 2. Negative print, 12 Jun 75 LANDSAT MSS7. Overlay is identical to that seen in Figure 1.

TABLE I SURFACE WATER INTERPRETATION/DIGITIZATION DATA

Sec No	No. Townships	Manhours Interp	Manhours Digit.	Key-Punch Cost ($)	MAPCLASS Cost ($)	Plot Cost ($)	Correction Manhours
1	30	3	12	26 60	6.15	2 00	5
2	12	1 5	3	6 30	3.45	1 45	1 5
3	24	1 8	9 5	19 30	10.20	1.80	4
4	16	1 9	3 3	8 40	4.50	1.55	2.8
5	20	2 2	6 4	11 80	5 70	1.70	3 3
6	12	.7	.8	7 30	4 20	1.45	1 5
7	8	1 0	1.3	7 10	3 45	1 40	1.5
8	12	1 0	4.5	10 30	5 25	1 45	2.5

TABLE II ESTIMATED COSTS SUMMARY

Sec	Total Cost
1	$132.75
2	44 2
3	103.3
4	47 77
5	68 12
6	29 15
7	33 15
8	55 00
Subtotal	$513 44
Material	50 00
Total Cost	$563 44

The interpretation of a township was arbitrarily selected from the ZTS data and masked off so that only the township and interpreted surface water was visible. At a resolution of 256 pixels/57 mm, there are 36 pixels per grid cell, i.e. each cell should be six pixels wide. Line printer maps of the digitized data resulted in the confirmation that 65 of the 69 bodies of water within the townships had been digitized. It is assumed the four not digitized were on the edge of a pixel. Thus far, the major problem is consistantly obtaining a digitized sample of exactly 144 x 144 pixels (which allows for an even six pixels per grid cell). Once this problem is alleviated, an evaluation on the costs and accuracy of the procedure can be conducted. An aggregation program has been prepared but is, as of yet, untested on this auto-entry procedure.

The DNRD representative has been provided 1 250,000 prints of a July 27, 1975 LANDSAT color composite, 2 June, 12 June, and 27 July MSS7, and 3 Dec 7 MSS5. The prints will be interpreted by DNRD personnell. Data to be extracted includes. surface water, agricultural land, rangeland, forested area, and urban area. MSS7 data will be used for surface water interpretations and the winter imagery will be used to assist in mapping forested areas. The standard false-color composite will be interpreted for agricultural, urban and rangelands. The interpretations and associated data will be used in subsequent evaluations of LANDSAT data.

State Planning Bureau

LANDSAT CCT'S for scenes 2186-17004 (27 July 75) and 2131-16551 (2 June 75) have been ordered and received. Digital analysis of land use will be conducted using these scenes. Comparisons between the results

of the land use algorithms, a variety of visual interpretations of the same scenes, aircraft, and ground truth data, should provide sufficient data to evaluate the accuracies and cost-effectiveness of these various data sources.

Game, Fish, and Parks

Forest-typing studies, in particular aspen grove locations, has taken on added importance to GF&P personnel. The Department was involved in a study which indicated pulverized aspen to be a good cattle feed. Black Hills aspen groves may now become an asset rather than the liability of the past. Potential development includes planned harvesting of aspen for use as a feed supplement. Development of a method for locating aspen groves has resulted in GF&P initiation of this aspect of the project.

A forestry-oriented representative of GF&P did collect ground truth data for use in training interpreters. However, use of the data was not practical as the ground-checked areas were simply too small (e.g. single trees) This situation may be normal when one is converting from thinking "at ground level" to thinking at the areal extent associated with remote sensing surveys. An RSI representative explained why such restricted data is not applicable. Subsequent ground truth information has located large aspen stands and will be usefull in developing methods of aspen interpretations. U.S. Forest Service forest-typing maps of certain areas have been obtained for added interpreter training.

Initial efforts center on distinguishing between deciduous and coniferous trees. Once this procedure has been defined it remains to separate the aspen groves from the deciduous stands. Visual interpretation of 1:1,000,000 winter LANDSAT data was conducted on the ZTS, registered

to 1:250,000 USGS Quadrangle maps. It was theorized that, in a forested area, the tree canopy would block reflectance of snow covered non-forested areas, allowing for a visual interpretation of the forested areas. Negative prints were chosen for the interpretation as the interpreter expressed preference to mapping the white (i.e. "highlighted") forested areas as opposed to the normal, dark forested areas. An example of the imagery and accompanying interpretation is seen in Figure 3. With limited cross referencing to RB-57 imagery, the interpreter was able to distinguish forested, mixed, and non-forested areas. Interpretation accuracies have not, as yet, been analyzed. It was then theorized that superimposing this winter forest boundary interpretation on a summer color composite would allow distinction between coniferous and deciduous stands. Referring to Figure 4, it can be seen that within the forested areas, there are essentially two shades of red a very dark red, usually associated with coniferous stands, and a brighter red associated with non-forested grassland and deciduous forests. The overlay of the winter interpretation has been superimposed on this color composite. Theoretically, the bright red forested areas would be deciduous trees. However, GF&P and U.S. Forest Service knowledge of the area, and inspection of RB-57 data for the area labeled A on the overlay resulted in the conclusion that this interpretation would result in excessive deciduous stands for the area. Further investigations revealed that the tonal differences for this area in particular are indicative of forest density in addition to type.

Further analysis of the visual interpretations will allow for recommendations regarding a visual approach to LANDSAT forestry typing.

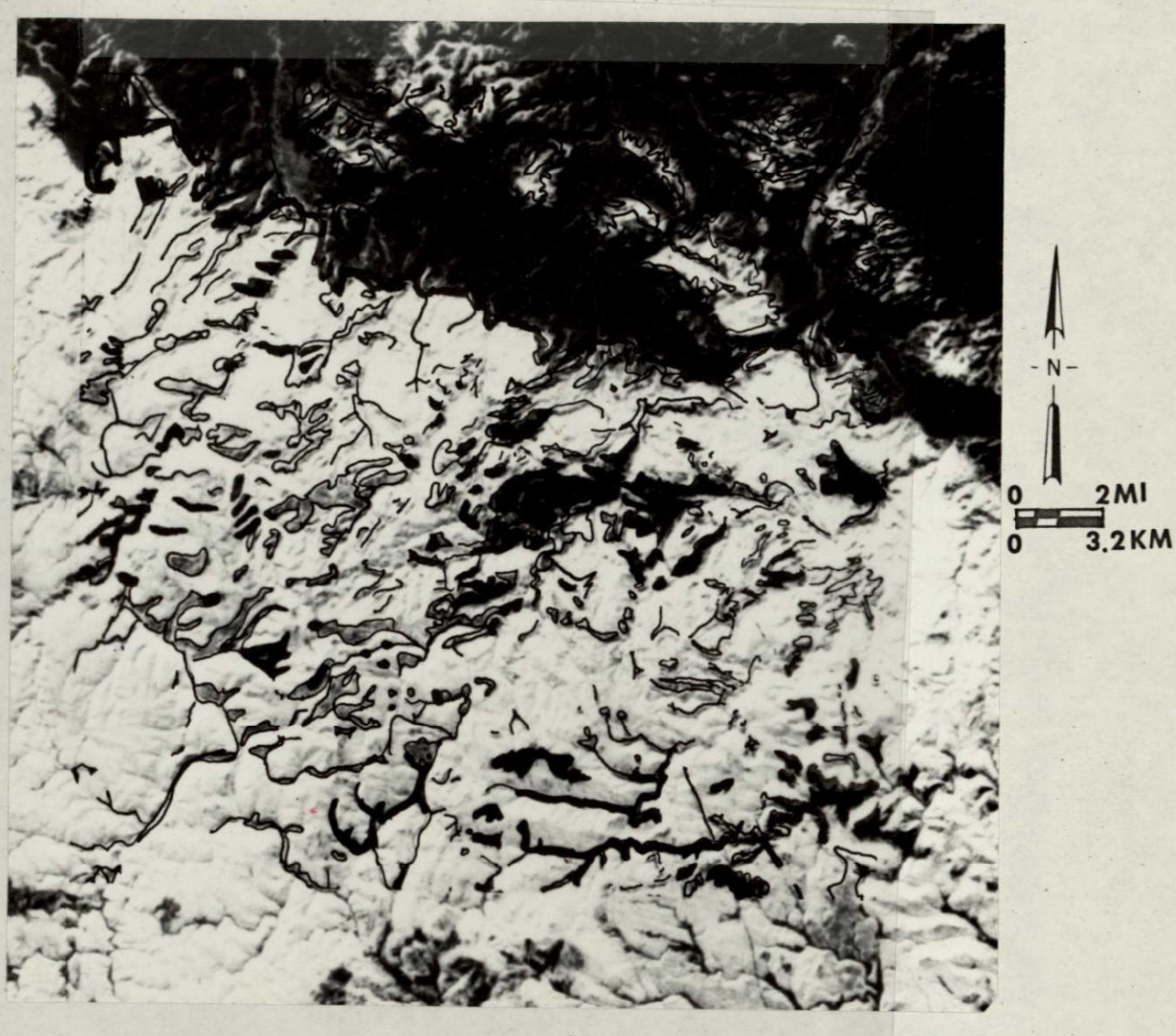

Figure 3. Negative print, 10 Jan 73 LANDSAT MSS5. Solid heavy line is boundary of forest. Outlined areas to the north are forested, outlined areas to the south are mixed or non-forested (dark).

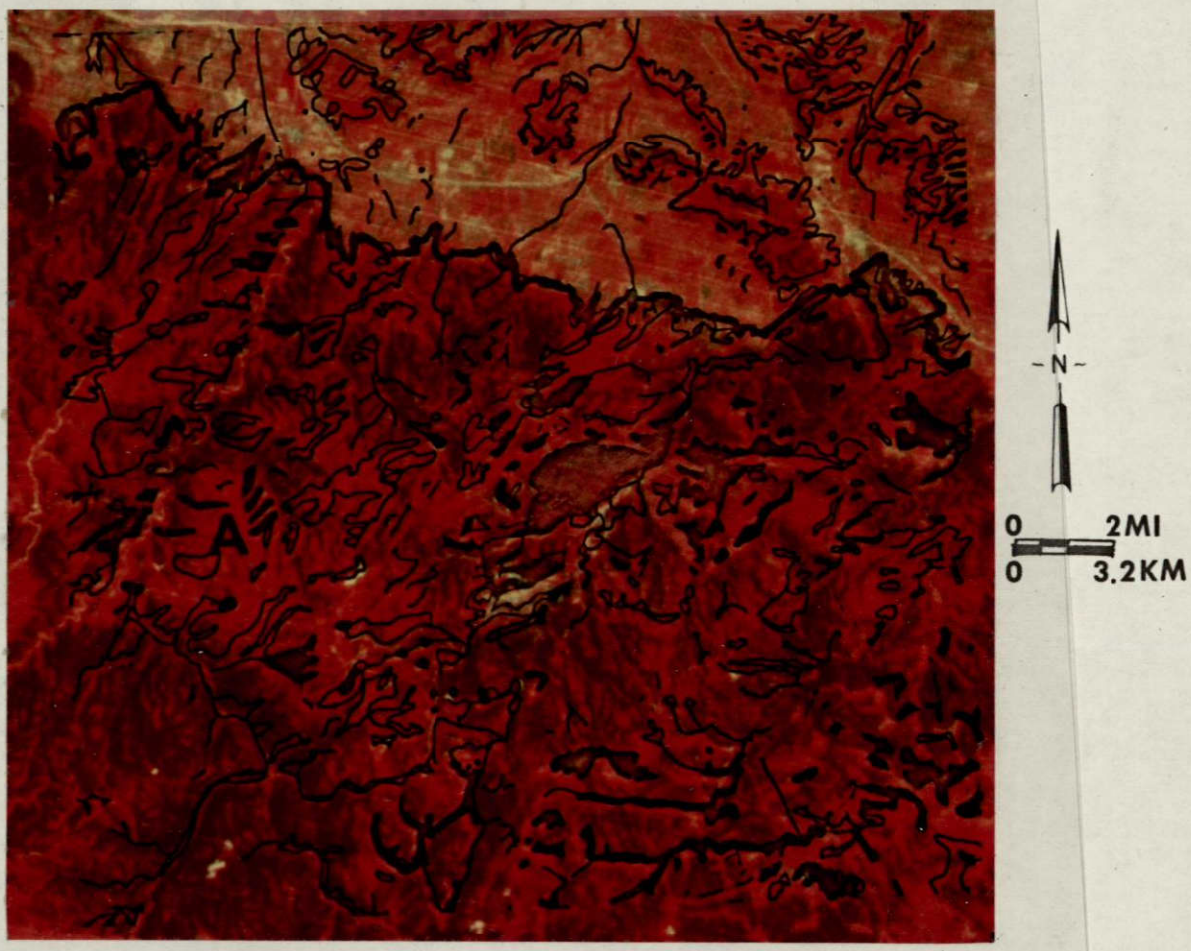

Figure 4. LANDSAT color composite, 27 Jul 75. Area and overlay are identical to Figure 3. Area "A", originally interpreted as deciduous trees, is low-density pine.

Digital analysis, of LANDSAT CCT's will be applied to forest-typing studies.

Diseased forestry studies have centered around the interpretation of low altitude aircraft imagery. Identification of dead trees is readily accomplished on color IR film, with varying shades of green indicating what GF&P officials interpret as old and new kills. Visual interpretation of June RB-57 imagery did not reveal the infested areas recorded by the low altitude data. Visual interpretation of LANDSAT data did not reveal the diseased forest areas. Digital analysis of both aircraft and LANDSAT data will be evaluated for applicability in mapping and monitoring diseased forest areas.

A mid-November meeting with the GF&P range specialist provided an opportunity to practically employ LANDSAT data in a department decision-making process. Missouri River bottomlands were inundated as a result of the construction of Big Bend and Oahe dams. The U.S. Army Corps of Engineers has suggested five areas for potential return to the state of South Dakota as partial mitigation of wildlife habitat losses incurred through the inundation of these bottomlands.

The Two-Rivers Ranch area is at the confluence of the Belle Fourche and Cheyenne Rivers, Figure 5. Two-Rivers is one of the suggested mitigation areas and was for that reason included by GF&P as an intensive study site for this project. A wildlife management plan was to be prepared for each of the five areas. On Thursday, November 13, GF&P personnel relayed the information that the deadline for preparation of the plans had been substantially advanced. Management plans were required by Wednesday, November 19. An RSI representative met with the GF&P range

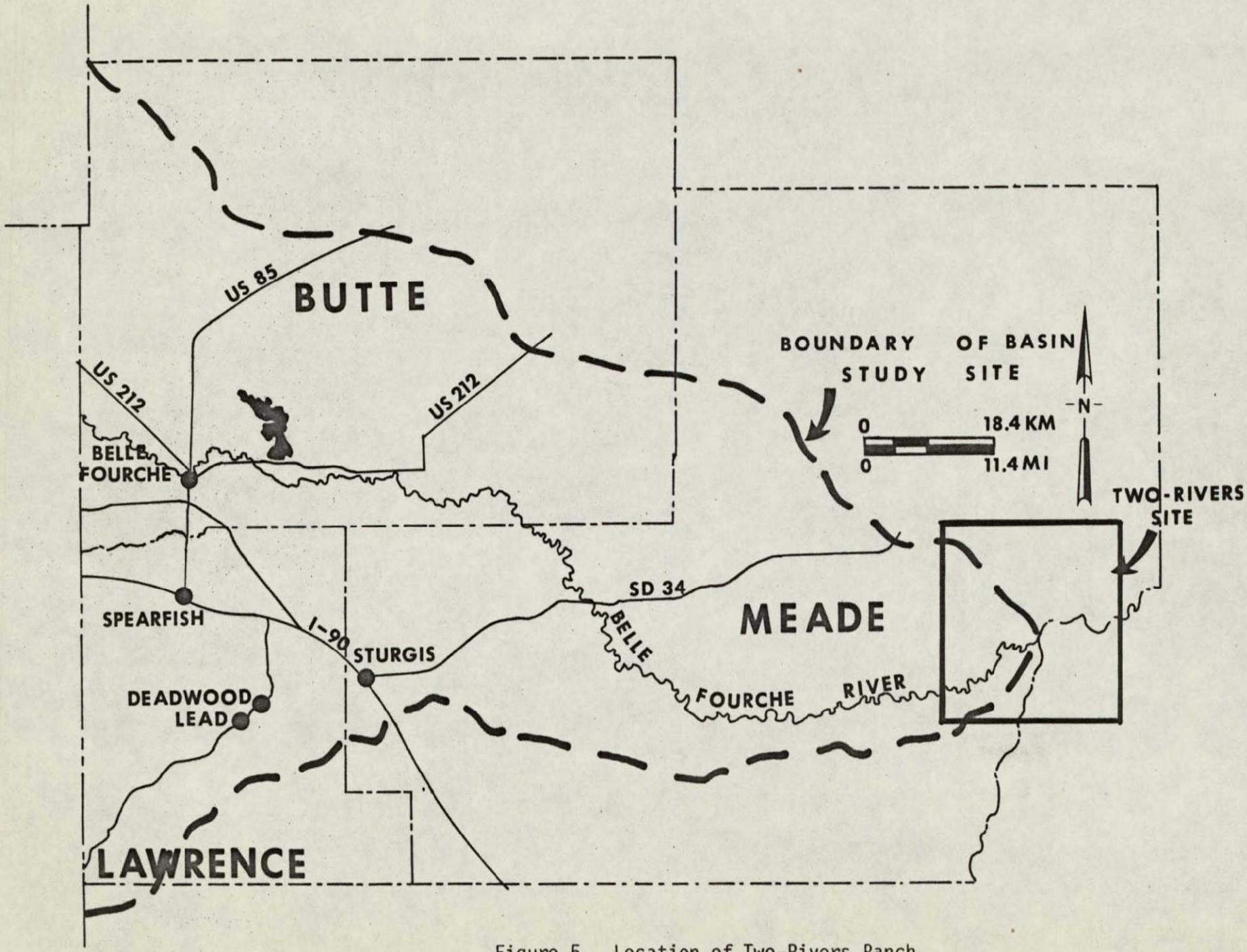

Figure 5. Location of Two-Rivers Ranch

specialist on Monday, November 17. Color and color IR RB-57, and LANDSAT MSS5, 7 enlargements were prepared and brought to the working meeting - also prepared was a black and white (red filter) mosaic of low altitude data collected by RSI over portions of the ranch area. Soils information, as interpreted from LANDSAT and aerial photography through NASA Grant No. 42-003-007 also proved valuable.

The proposed boundary of the 14,453 ha (35,700 acre) mitigation land was transferred to LANDSAT data, Figure 6. Surface water interpretations were conducted from early spring (wet) and mid-summer (dry) LANDSAT MSS7 data. Interpretations provided data on surface water acreages within the proposed boundary and also within a 435 km^2 (168 mi^2) area surrounding the ranch site. Interpretations during wet and dry periods allowed basic conclusions to be drawn regarding the relative permanence of the surface waters. Surface water densities (surface water area per land area) were then calculated for the land within the proposed boundary and the 435 km^2 surrounding the site. Based on these data, the range specialist was able to make recommendations on the distribution of water and location of future impoundments required to bring the water density of the land within the boundary up to a level commensurate with that of the level associated with the surrounding 435 km^2.

Soils information allowed the range specialist to develop predictions on range cover and associated production capacity in terms of ability to support wildlife. Land use data (i.e. agricultural acreages) were determined from LANDSAT MSS5 for the land within the proposed boundary and the surrounding 435 km^2. Such information might prove invaluable in establishing an environmental assessment of converting the entire

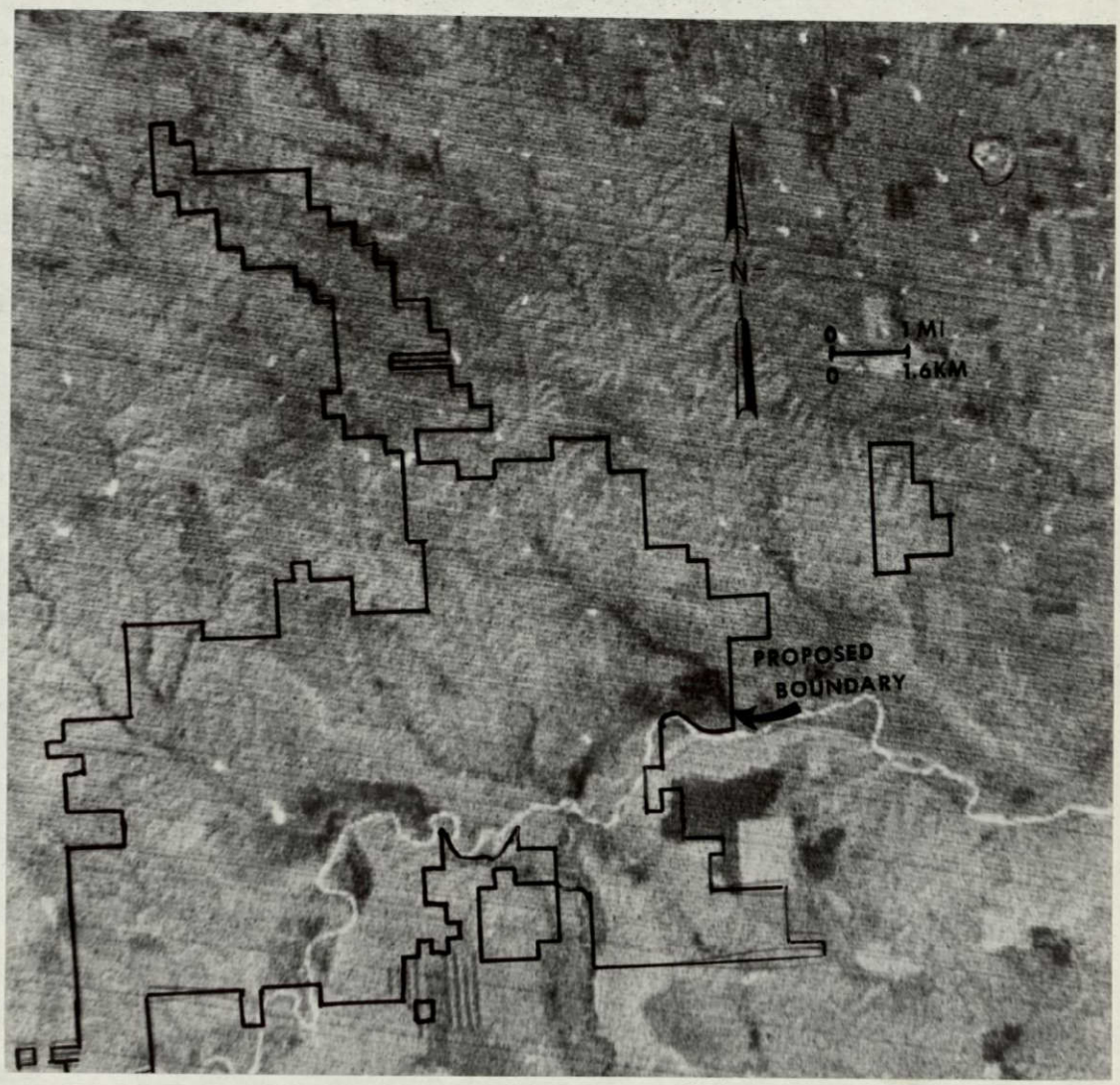

Figure 6. Proposed boundary of mitigation land as transferred to LANDSAT MSS7 of 26 Jul 75.

mitigation land into wildlife production and associated uses. Forested and brush areas were interpreted from the low altitude mosaic. This data was useful in evaluating the habitability of the area for a variety of game species. The data interpreted via this session was used in the preparation of a Game Management Plan presented to the Corps of Engineers and reviewed in a public hearing.

The same GF&P representative involved in this interpretation session has now been given LANDSAT imagery of the Belle Fourche River Basin. Interpretations similar to those being conducted by DNRD personnel are now underway. Consideration is being given to the development of a wildlife management plan for the Belle Fourche River Basin, based on the procedures involved in the Two-Rivers study.

FUNDS EXPENDED

Total funds expended through November 30, 1975 $46,866 13

This does not include total costs incurred by state agency participants as they invoice on a quarterly basis.

DATA USE (As of December 3, 1975)

Value of Data Allowed - $15,144

Value of Data Ordered - $ 5,724

Value of Data Received - $2,888

AIRCRAFT DATA

NASA RB-57 data collected June 25 and July 15 was received and, except for excessive clouds over portions of the test site and lack of color IR data over portions of the test site, the data is useful. The imagery has been used in locating aspen training sites and in spot-checking the accuracy of surface water interpretations and digitization

procedures. The data will become increasingly valuable as extensive evaluation of the LANDSAT interpretations begins. The U-2 data of September 1975 has not been received for evaluation and implementation into the project. RSI aircraft data was used in the Two-Rivers study and has provided basic data for continued studies on aspen locations and diseased tree information.

PROGRAM FOR NEXT REPORTING PERIOD

Visual interpretation of LANDSAT data will continue. Use of prints as a data source will be compared with use of the transparency ZTS combination. Interpretation scales of 1 250,000 and 1.125,000 will be evaluated. Comparison between various LANDSAT interpretations, RB-57 and U-2 data, RSI, and ground truth data will allow for basic recommendations regarding the applicability of visually interpreted LANDSAT data. Digital land use maps will be prepared from LANDSAT CCT's and compared with the data obtained through the data sources mentioned above. Known aspen stands and diseased forest areas will be located on the CCT and work on the applicability of digital analyses will begin. Work will continue on the automatic entry of data into the MAPCLASS data base. Evaluation of the aggregation program and cost comparisons with conventional digitizing methods will be emphasized.

CONCLUSIONS

Active participation by state agency personnel in the interpretive procedures is increasing The value of LANDSAT data for certain applications and situations has been demonstrated to GF&P through the Two-Rivers experience. The DNRD representative has consistently stated a need for surface water inventories and land use information. With

the "believability" of LANDSAT interpretations beginning to establish itself in the minds of these two agencies, they are gradually becoming more involved in providing interpretation input into the LANDSAT evaluation procedures. Direct involvement by the SPB will increase with the evaluation of digital land use mapping. It is felt that only through the sometimes slow processes of exposure, osmosis, acceptance and participation, can each of the involved South Dakota governmental departments assist in the evaluation of and have confidence in the application of LANDSAT data for their respective departments.

RECOMMENDATIONS

Reduced turn-around time for both aircraft and LANDSAT data products would allow for earlier initiation of studies and contribute to the timeliness of the results.


RECEIVED
NASA STI FACILITY
INPUT BRANCH